The NASA SCI Files™
The Case of the
Radical Ride

Segment 3

The tree house detectives and Dr. D are STILL stuck in traffic. Things are looking grim, and they might miss the awards ceremony after all. To stay focused on the positive side of being stuck, the detectives continue to work on their project from the van. While waiting, Dr. D explains the importance of redesign, the next step in the engineering design process, by explaining how he redesigned his personal hovercraft. In the meantime, R.J. visits Jeff Robinson at NASA Langley Research Center to learn more about the redesign process involving the Hyper X project, and Bianca and Kali continue to wait patiently outside the auditorium. Bianca begins to think that they need to learn more about future transportation, and she decides to dial-up the NASA SCI Files™ Kids' Club members at Golightly Educational Center in Detroit, Michigan. After reading Wendy's and Rosie's report from the Channel Tunnel about a possible transatlantic tunnel, the students decide to conduct magnetic experiments with their mentors from the Society of Women Engineers (SWE) to learn more about how a maglev train operates. Wishing they had their own maglev train, the detectives and Dr. D continue to move at a snail's pace while Bianca and Kali determine that more research is needed.

Objectives

The students will

- build a model hovercraft and conduct tests for optimal size and placement of air holes.
- understand the importance of the iterative (redesign) process in engineering.
- learn how a fault tree is used in the engineering design process.
- conduct an experiment to understand magnetic force.
- understand how improved travel impacts society and the world.
- create a maglev train to understand magnetic force.

Vocabulary

fault tree—a graphical representation of the chain of events in the engineering design process that is used by engineers to analyze their designs from a top-down approach to avoid problems or find solutions

Hyper-X Program—a series of small, experimental research aircraft designed to test a new propulsion system called a scramjet.

maglev—an electrically operated high-speed train that glides above a track by means of a magnetic field (magnetic levitation)

magnetic field—a region of magnetic forces around a magnet

magnetism—a force of attraction or repulsion caused by an arrangement of moving electrons producing a magnetic field

scramjet—a new type of propulsion system that uses the speed of the aircraft to compress incoming air to mix and burn it much like in a car engine. The burned fuel-air mix then expands out the back of the engine and propels the vehicle forward.

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 3 of *The Case of the Radical Ride*, discuss the previous segment to review the problem and assess what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on **Tools**. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use this section of the web site to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have occurred during previous segments. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 2.
5. Read the overview for Segment 3 and have students add any questions to their list that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the **Educators** area of the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program so they will be able to answer the questions. An icon will appear when the answer is near.

7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the **Educators** area of the web site ahead of time for students to copy into their science journals.

View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Radical Ride* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about transportation, the engineering design process, identifying a problem, finding a solution to the problem, making a model, testing the model, and analyzing the test data. Organize the information, place it on the Problem Board, and determine whether any of the students' questions from the previous segments were answered.
4. Decide what additional information is needed for the tree house detectives to better understand engineering design and the future of transportation. Have students conduct independent research or provide them with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
5. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under After Viewing on page 15 and begin the PBL activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, PBL activity:

   Research Rack—books, Internet sites, and research tools

   Problem-Solving Tools—tools and strategies to help guide the problem-solving process.

   Dr. D's Lab—interactive activities and simulations

   Media Zone—interviews with experts from this segment

   Expert's Corner—listing of Ask-an-Expert sites and biographies of experts featured in the broadcast
7. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.
8. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the **Research Rack** in the **Tree House** and find the online PBL investigation main menu section, **Problem-Solving Tools**, and the **Tools** section of the **Educators** area for more assessment ideas and tools.

Careers

aerospace engineer
materials engineer
computer engineer
wind tunnel technician
physicist

Resources (additional resources located on web site)

Books

Haslam, Andrew (Designer) and Glover, David: *Building (Make it Work! Science Series: The Hands-On Approach to Science)*. Two-Can Publishing, LLC, 2000.
ISBN: 1587283514.

Haslam, Andrew (Designer) and Glover, David: *Machines (Make it Work! Science Series: The Hands-On Approach to Science)*. Two-Can Publishing, LLC, 2000.
ISBN: 1587283573.

McCormack, Alan J.: *Inventor's Workshop*. Fearon Teacher Aids, 1981.
ISBN: 0822497832

Rinard, Judith E.: *The Book of Flight: The Smithsonian National Air and Space Museum*. Firefly Books, LTD, 2001. ISBN: 1552095991.

Thomes, Joann F.: *How To Do Inventions for Science Fair Projects*. Frank Schaffer Publications, 1997. ISBN: 0764701061.

Yolen, Jane: *My Brothers' Flying Machine.* Little, Brown Children's Books, 2003.
ISBN: 0315971596.

Web Sites

What You Need To Know About: Hovercraft
Visit this web site to learn how a hovercraft works and to read about the man who invented it. Great links are provided for further research.
http://inventors.about.com/library/inventors/blhovercraft.htm

NASA Langley Research Center—Aeronautics
Visit this web site to learn how NASA Langley Research Center is helping change the way the world flies. Find more information on flight simulators, the 757 aircraft, aviation safety and security, and much more.
http://www.larc.nasa.gov/research/inside_pages/aeronautics.htm

Federal Aviation Administration—Careers in Aviation
If you're thinking about a career in aviation, this site is a must. Learn all about aviation careers from skycaps to test pilots.
http://www.faa.gov/education/rlib/career.htm

NASAexplores: Hyper X: Greased Lightning
Read an engaging article written for K–4 students about the fastest plane in the world, the X-43. There are also student activities and an educator guide.
http://www.nasaexplores.com/show2_k_4a.php?id=02-031&gl=k4

Nova Site: Faster Than Sound
It has been 50 years since test pilot Chuck Yeager broke the sound barrier. Visit this site to hear Yeager and others describe those early days and to discover what creates a sonic boom, or to find out about the latest attempts to beat speed records on land, water, and in the air. Student activities and a teacher guide are included.
http://www.pbs.org/wgbh/nova/barrier/

NASAexplores: Lowering the Boom
Read an exciting article about how NASA is working with government and industry partners to find ways to reduce the noise and shock waves associated with supersonic flights. Student activities and an educator guide are included.
http://nasaexplores.com/show2_articlea.php?id=04-017

Howstuffworks: How Maglev Trains Work
Visit this web site to find out about electromagnetic propulsion, future development of the maglev train, and much more.
http://travel.howstuffworks.com/maglev-train.htm

Fundamentals of Maglev
Learn, in simple terms, the basic principles of how a maglev train works. Also find out about the various types of maglev trains, how they float, and other related issues.
http://www.calpoly.edu/~cm/studpage/clottich/fund.html

New Scientist: First Passenger Maglev Train Set for Liftoff
Read an article and find out all the details about the first magnetic levitation passenger train that began operations in January 2003 in Shanghai, China. The train will carry passengers at a top speed of more than 400 km (250 mph)!
http://www.newscientist.com/news/news.jsp?id=ns99993153

Popular Science: Transatlantic Maglev
Catch a train in New York and arrive in London just an hour later! Read about the proposed neutrally buoyant vacuum tunnel submerged 150 ft to 300 ft beneath the Atlantic Ocean's surface and anchored to the sea floor, in which trains zip along at speeds up to 4,000 mph.
http://www.popsci.com/popsci/science/article/0,12543,599827-2,00.html

Activities and Worksheets

Just Hovering Around

Problem

To design and build a model hovercraft

Background

In *The Case of the Radical Ride*, Dr. D is building his own personal hovercraft by using the engineering design process to design, build, test, and redesign (as necessary) a model hovercraft. To get maximum lift, Dr. D needs to optimally place holes in the plastic on the bottom of the hovercraft, but he needs your help to determine the size, placement, and number of holes.

Remember to make sure that there are vent holes near the plastic lid attached to the bottom. Also, leave space between the holes so there is plenty of plastic between each of them. If the holes are too far away from the center, they will become plugged when the plastic sheet lies flat against the floor. If the space between holes is too narrow, the plastic will tear. Consider using duct tape to reinforce any thin, narrow necks of plastic between the holes.

Materials

- heavy cardboard
- scissors or razor knife
- compass
- metric ruler
- heavy plastic
- duct tape
- marker
- shop vacuum
- small plastic lid
- brad
- weights of various masses

Procedure

1. In your group, discuss the basic design of a hovercraft. Conduct research if necessary.
2. On a piece of cardboard, draw a circle with a 20-cm diameter.
3. Carefully cut along the drawn line.
4. Place the cardboard circle on top of the heavy plastic and use a marker to trace a circle about 3–4 cm larger than the cardboard (26–28 cm in diameter).
5. Find the center of the cardboard circle and mark it with a small dot.
6. Use a ruler and draw a solid line from the center dot to anywhere on the outer edge of the disk. See diagram 1.
7. Measure the length of the line and mark a dot in the middle.
8. Center the hose of the shop vacuum over the dot mark and trace around the outer edges of the hose.
9. Cut a hole along the line traced.
10. Lay the disk in the center of the plastic circle and fold up the edges over the cardboard circle and tape. See diagram 2.
11. Use duct tape to secure the plastic to the top of the cardboard. Make sure that the plastic is drawn tight and that all edges are sealed.
12. With adult supervision, punch a hole through both the center of the cardboard circle and the plastic bottom.
13. With adult supervision, punch a hole in the center of the small plastic lid.
14. Place the plastic lid on the plastic side of the circle and secure with a brad. See diagram 3 on page 53.
15. From your discussion and research, determine the placement, size, and number of holes you should place in the plastic to produce optimal lift of the hovercraft.

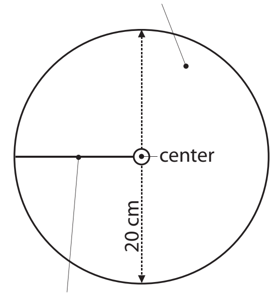

Diagram 1

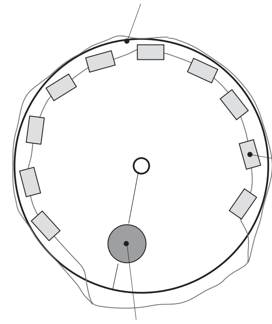

Diagram 2

Just Hovering Around (concluded)

16. Use a compass to draw a place for each hole and cut them out. Note (Optional): To avoid mistakes, design a paper template with circles where the holes should be. Once all group members agree to the template, cut out the places where you want holes on the template. Place the template on top of the plastic and trace the areas where the holes should be. Cut holes in the designated areas of the plastic. See diagram 4.
17. Connect the shop vacuum to the cardboard circle and test your hovercraft. See diagram 5.
18. Devise a series of tests by using various amounts of weights to measure the distance the hovercraft lifts off the tabletop.
19. Record your test data in a chart to share with the class.
20. In your class, determine which group's design lifted the most weight to the highest level.

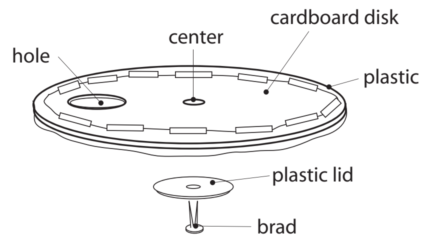

Diagram 3

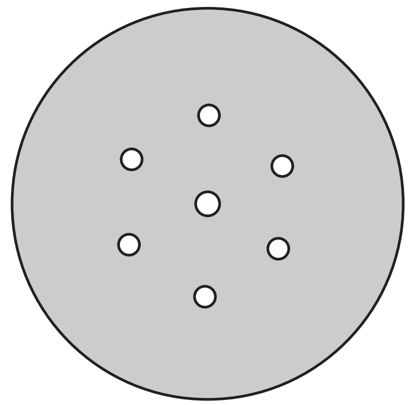

Diagram 4

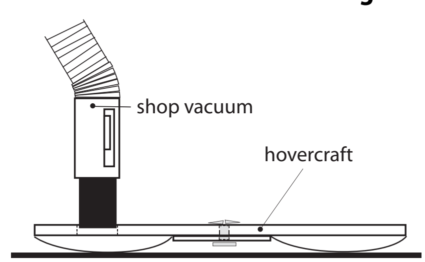

Diagram 5

Conclusion

1. Which design lifted the most weight? Why do you think it was the best?
2. How would you change your design next time?
3. Are there any other changes in the hovercraft design that you would like to make?
4. Dr. D's next problem is how to control the hovercraft. What do you recommend he try?

Extension

To build a large-scale model of Dr. D's hovercraft, visit
http://www.amasci.com/amateur/hovercft.html

The Iterative Process

The tree house detectives learned that designing is an iterative process. Iterative means that first you design something, build it, test it, and then you analyze the data from the tests. From the data, the design is modified over and over again until it is correct. To begin the iterative process for your chosen solution, carefully plan and draw your design. Remember to draw your design in detail and label it clearly, neatly, and correctly so that others will understand how it works. In your Designer's Log, draw a final copy and write a detailed description of your design.

Draw your design here:

Description of your design: ____

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Redesign, Redesign, Redesign

Purpose

To understand the importance of redesign in the engineering design process

Look around and you will see many different products—radios, televisions, cell phones, soda cans, pencils, bookcases, computers, paper clips, and so on. Everything you see began as an idea in someone's mind. Designers take their ideas and after much work, turn them into reality, but have you ever thought that something could be better? Have you ever had an idea about how to improve a product?

Dr. D explains to the tree house detectives that the engineering design process is actually an iterative process, which just means that you go through all the steps in the process again and again until you are happy with the final product. Dr. D also told the detectives that the product would probably never be "perfect" but that eventually an engineer decides that it is good enough for the purposes intended and stops the process. Sometimes, however, an engineer or inventor can decide much later that the product could be even better and will redesign it one more time. That is the beauty of the engineering design process—it is never really finished!

Procedure

1. Look around the room again and choose a product that you think could be improved. Write the product's name in the line provided.
2. Brainstorm a list of ways to make the product better and draw a web to display your ideas.
3. Choose one of the ideas and describe how you would redesign the product.
4. Share your idea for redesign with the class. Ask for comments and feedback.

Product Name: ___________________________________

Web of Ideas:

Redesign Ideas:

To a Fault

Purpose

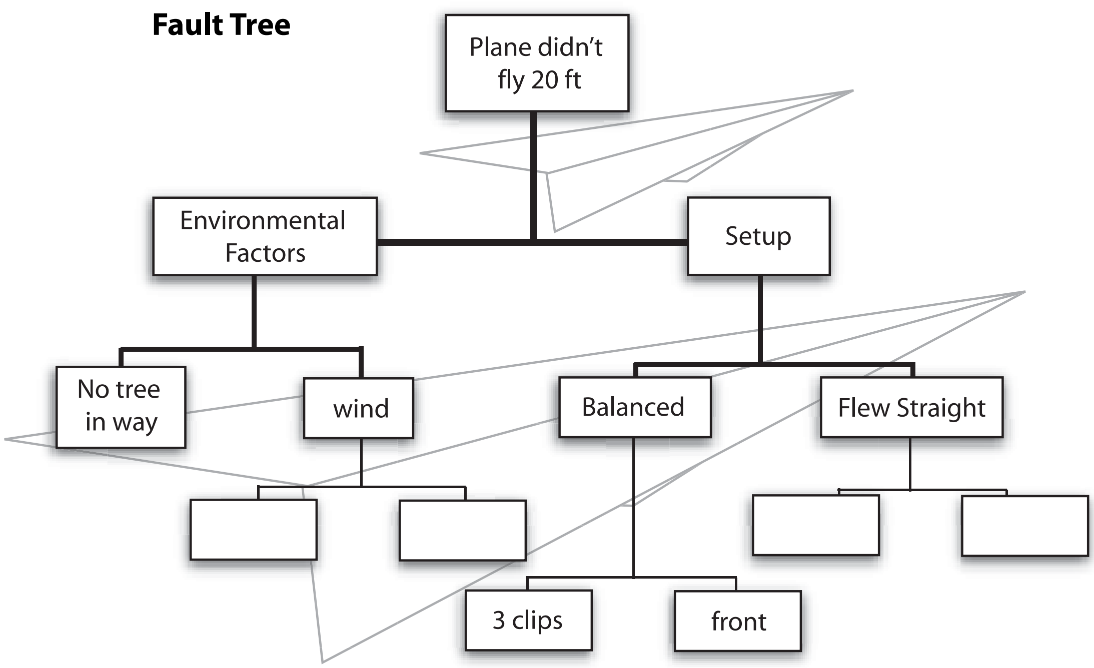
To learn how to analyze a design to determine problems

Fault tree analysis is a logical, structured process that can help designers identify potential problems. Fault trees are powerful design tools that can help engineers ensure that their designs successfully meet their objectives. Fault tree analyses are performed from a top-down approach. You begin by determining a top-level event and then work down to evaluate all the contributing factors that may lead to the top-level event's occurrence. It is a graphical representation of the chain of events in the design process.

For example, if you designed a paper airplane to fly 20 m and it only flew 5 m, the top-level event would be that the airplane did not fly 20 m. Also, the fault tree might be built to include, among other things, the manufacturing process and materials, the setup (plane is balanced and flies straight), the test procedure (throwing techniques), and any environmental impacts (strong wind blowing or trees in the way). You would need to take a look at each event in the fault tree and decide which, if any, contributed to the unsuccessful flight. Once you identify the factor(s) that led to the unsuccessful flight, you would decide if any changes should be made. If no factors contributed, then you should consider the possibility that the current design of the plane is not capable of flying that distance. Either way, it is back to the drawing board for another redesign!

When using the engineering design process, include a fault tree to help create a successful design. Use or copy a diagram like the one shown to help you design your own fault tree.

Fault Tree



A Levitating Idea

Problem

To understand magnetic forces and how they are used to create a maglev train

Background

Magnetism, like gravity, is a force that cannot be seen. Every magnet, however, has an area in which it exerts its force. This area or space is called the magnetic force field. The size of this field depends upon the strength and size of the magnet. All parts of a magnet do not show equal strength. The areas of greatest strength or attraction on a magnet are called the poles. If you suspend a bar magnet horizontally by a loop of thread, you will find that when the magnet stops swinging, one end will point north. This end is the north-seeking pole, or simply north pole. The other end is the south-seeking, or south pole. Magnets are usually marked with an N for north pole and an S for south pole. If you place similar poles together (N-N or S-S), the magnets will repel each other. If you place opposite poles together (N-S), the magnets will attract and stick to each other.

Materials

- 26 5/16-in. flat washers
- ceramic magnets: powerful 1 1/8-in. size
- 12-cm (3/8-in. diameter) wooden dowel
- metric ruler
- science journal
- *Note: These magnets are often hard to find but can be purchased at Radio Shack®.

Procedure

1. Place four magnets on the wooden dowel with opposite ends together so that they attract and stick together.
2. Place the fifth magnet on the dowel with similar poles together so that it repels the other magnets. See diagram 1.
3. Lightly tap the top magnet a couple of times.
4. Using a metric ruler, measure in millimeters (mm) the distance between the bottom of the top magnet and the top of the magnet right below it. See diagram 2.
5. Record the distance in your science journal.
6. Place two washers on top of the upper magnet. See diagram 3.
7. Lightly tap the magnet and washer so that they bounce slightly.
8. Measure and record the distance between the magnets.
9. Repeat steps 6–8 by adding two washers at a time until you have a total of ten washers.
10. Repeat steps 6–8 by using four washers at a time until all the washers are placed on the dowel.
11. Create a graph of your results.
12. Share your results with the class and create a class graph.

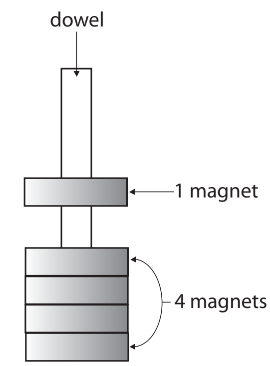


Diagram 1

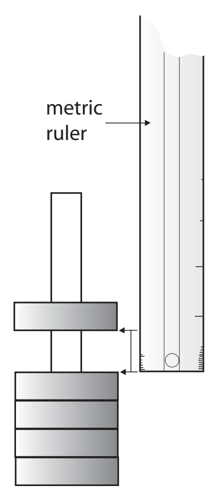


Diagram 2

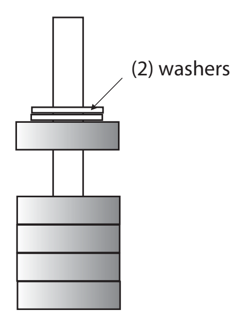


Diagram 3

A Levitating Idea (concluded)

Graph

MAGNETIC FIELD STRENGTH

Separation (mm)

Number of Washers

Conclusion

1. What happened as you added washers to the top magnet? Why?
2. Why was it necessary to add four washers at a time after adding ten washers?
3. How is magnetic force used to create a maglev train?

Extension

1. Conduct the same experiment by using only one magnet on the bottom instead of four. Repeat the experiment with two magnets on the bottom, then three magnets.
2. Conduct an experiment measuring the distance between two repelling magnets. Repeat with two magnets on the bottom and then with three magnets. How did the distance between magnets change as you increased the number of magnets on the bottom?

Answer Key

Just Hovering Around

1–4. Answers will vary.

A Levitating Idea

1. As washers were added to the top of the magnet, the distance between the two magnets decreased because when the masses were first added to the top magnet, the increased weight caused the top magnet to begin dropping. Magnetic force is stronger when magnets are closer together; therefore, the magnet stopped dropping when the increased magnetic force equaled the weight.
2. The graph flattens as the mass increases, showing that it takes a lot of mass to make a little change in separation once the two magnets get very close together. Remember that the magnetic field strength increases rapidly when magnets are close together. When there are 10 washers up top, the change in separation with only 2 additional washers would be so small it would be difficult to measure accurately. Therefore, it was necessary to add washers 4 at a time.
3. Magnetic force is used the same way in this experiment as it would be in the actual building of a maglev train except that the magnetic force would have to be much more powerful to levitate the train and passengers above the "tracks."

On the Web

Faster and Faster We Go!

1. Answers will vary, but students should be able to see that the time it takes people to go long distances has drastically decreased over the last 200 years.
2. Answers will vary but might include that our world has become "smaller," and we travel more frequently and to places farther away.
3. Answers will vary but might include that our world will become even smaller and we will travel farther and faster. With new technology, someday we might go to the Moon for a vacation or to Tokyo for lunch.

Riding on Air!

1. Opposite poles repel and create a magnetic force field between them. If it is strong enough, the force field separates any objects above and below it.
2. No, regular magnets would not create a force field strong enough to support the weight of a train and its passengers. For a better understanding conduct the activity, A Levitating Idea, on page 57-58 in the educator guide.
3. Answers will vary but might include that it is a cleaner form of transportation and that the trains have the potential of traveling at great speeds.